Comparing in situ sampling methods in a deep groundwater well

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Death Valley Regional Flow System (DVRFS)

Well depths

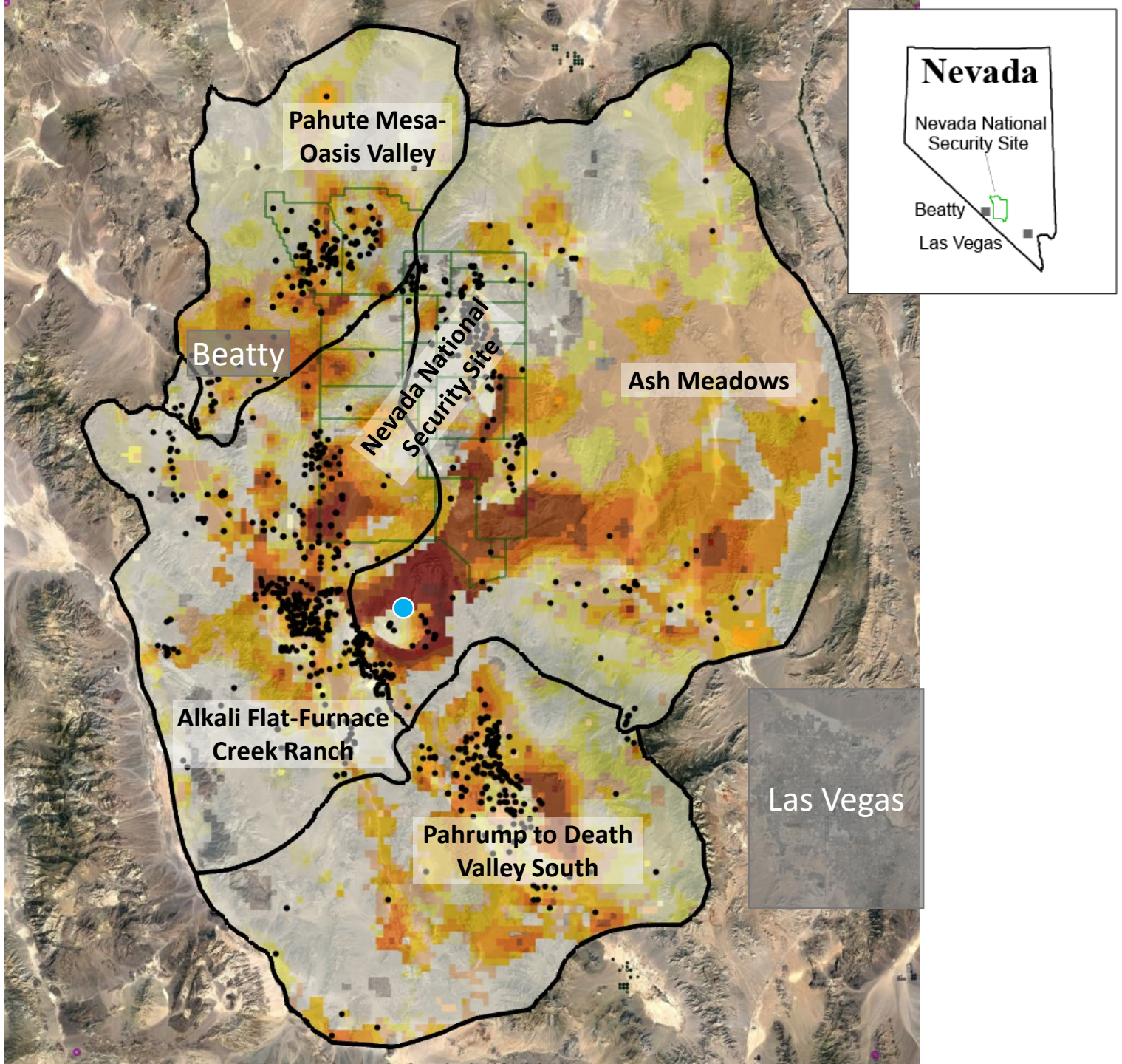
100s to more than 10,000 feet below land surface

Groundwater level

10 to more than 2,000 feet below land surface

Modeled Transmissivity (ft^2/day)

- 0.000 to 0.100
- 0.100 to 10.00
- 10 to 100
- 100 to 10,000
- 10,000 to 100,000



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Groundwater sampling limitations for deep wells

Pump capabilities

- High enough pump rate to purge deep wells
- Strong enough motor to lift water 2,000 feet
- 1,000’s of feet of wireline
- Portable

www.altramotion.com

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Purge Water

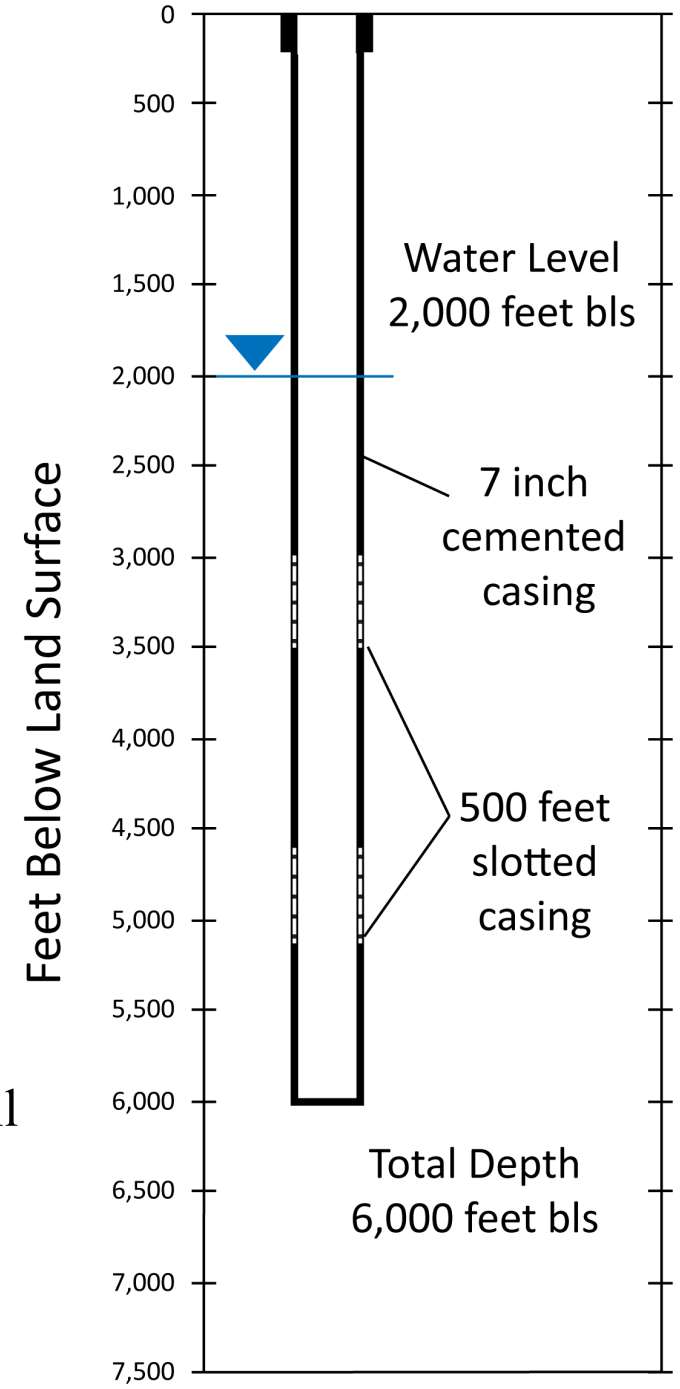
- Contamination
- Where to put it

Representative Sample

- Composite Sample

Idealized Well
4,000 feet of water in a 7 inch well

3 purge volumes =
24,000 gallons



Research Question

- Can in situ groundwater sampling provide representative formation samples and be replicated over multiple sampling events?
  - Major Ions
  - Trace Elements
  - Stable Isotopes
  - Radioactive Isotopes (Tritium)

Tracer Sample Hole #1, Amargosa Desert

Photo by R. Paylor

Tracer Sample Hole #1

Total Depth 664 feet

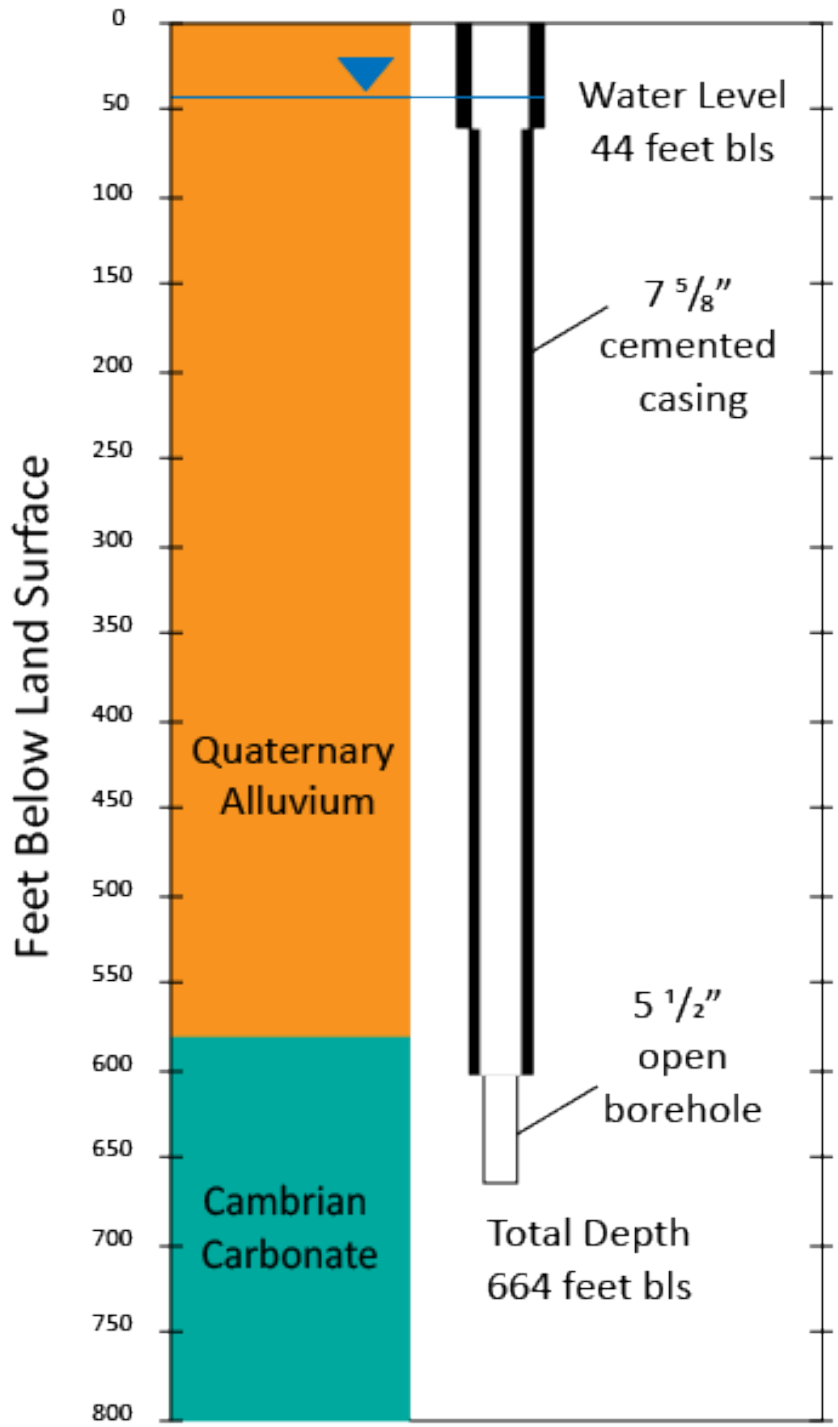
Water Level 44 feet

Transmissivity

- 100,000 feet^2/day

Limited hydraulic gradient

- 10^{-4} to 10^{-5}



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Claassen and Cordes, 1975, Two-well recirculating tracer test in fractured carbonate rock, Nevada, Hydrologic Sciences Bulletin, p. 267.

In Situ Groundwater Sampling Methods

In Situ Sample

- Sample comes from a specific depth from within the well bore

  Targeted sample, not composite
- No mobilization of particulates, colloids, or contaminants
- No purge waters
- May represent a more natural flow condition type sample

In Situ Methods

1. Passive Samplers
   - Deployed already filled with water

     Diffusion due to chemical gradient between deployed water and aquifer groundwater
   - Water that is flowing through the open interval of a well under normal condition
   - Integrated sample
2. Discrete Depth Bailer
   - Deployed empty and filled at specific depth
   - Instantaneous sample

Biggest Challenge

Sample Water Volume LIMITED

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Passive Sampler: Regenerated Cellulose Dialysis Membrane (RCDM)

Bag deployed with DI water
Diffusion across the entire length of bag
Filtered water sample collected
Sample volume 1,000 ml
Bag must stay wet and cold

Deployment modifications

Internal structure to keep bag open
Protective shroud

Deployed twice in 2018

- Campaign 1: 21 day deployment
- Campaign 2: 27 day deployment

Depth Discrete Bailer (DDB)

Metal chamber closed at deployment
Value opened at specified depth from surface
Instantaneous sample
Maximum sample volume 1000 ml

Deployment modifications

Sampling port built into bottom

Deployed three times in 2018

- 10 bailed samples collected for each campaign

?How does chemistry change over each bailed sample?

Research Design

Day 1:

Deployment Day – RCDM Samplers

Day 21 or 27:

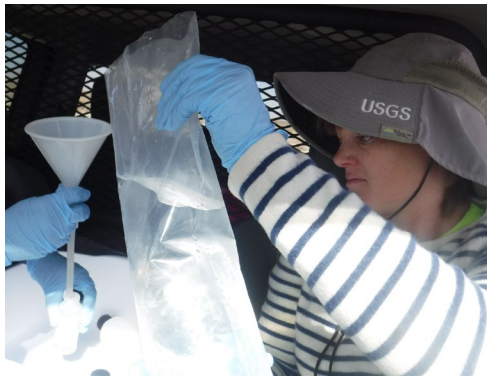
Groundwater Sampling – RCDM

- Retrieve and collect groundwater samples

Day 22 or 28:

Groundwater Sampling – DDB

- Depth Discrete Bailed deployed 10 times



Quality Assurance

Deployment Day – RCDM Samplers

1. Paired samplers
2. Equipment Field Blanks
   - Deionized water from storage bag

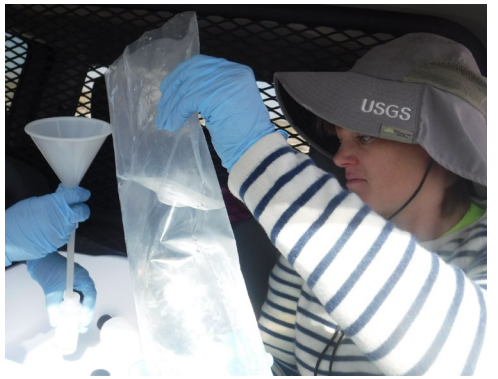
   Major ions, trace elements, and isotopes

Groundwater Sampling – RCDM

1. Paired samplers
2. Replicates within each paired sample

Groundwater Sampling – DDB

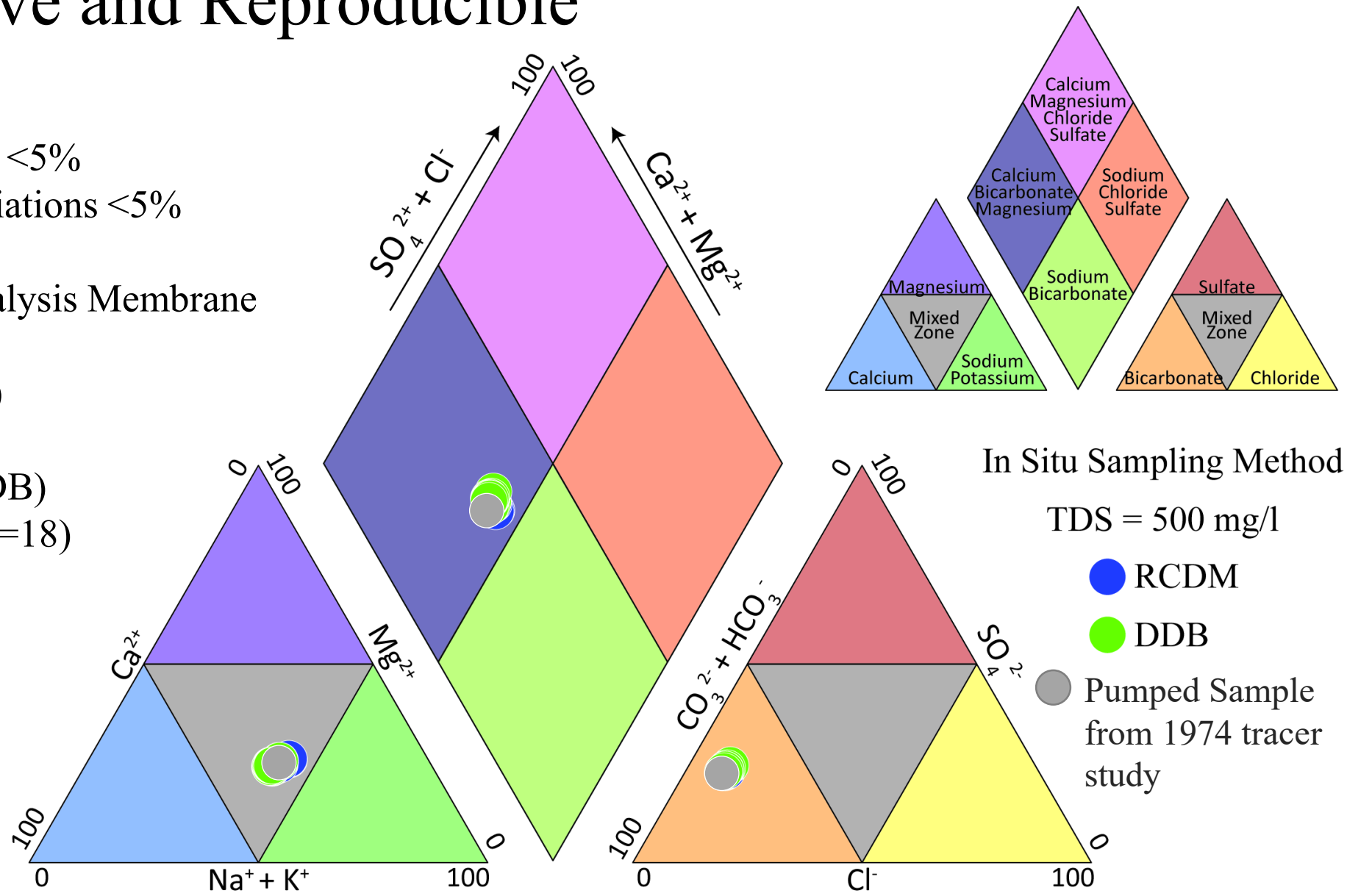
1. Equipment field blanks using ultra clean water
2. Replicates of isotopes in each bailer sampler



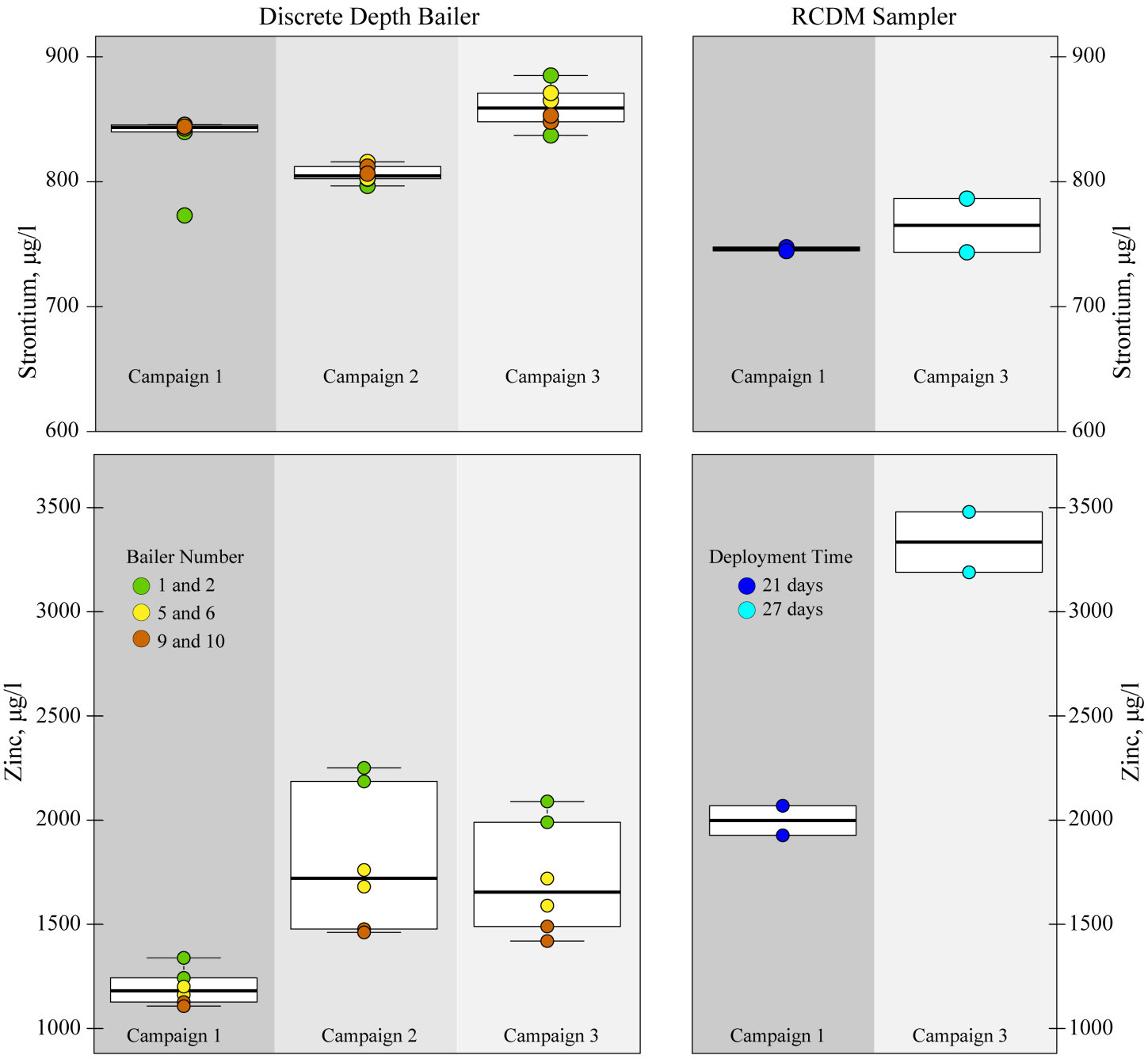
Major Ion Results
Representative and Reproducible

Charge balance <5%
Relative standard deviations <5%

- Regenerated Cellulose Dialysis Membrane (RCDM)
  Campaigns 1 and 2 (n=4)
- Discrete Depth Bailer (DDB)
  Campaigns 1, 2, and 3 (n=18)



Trace Element Results



Historic data lacking for some variables

DDB

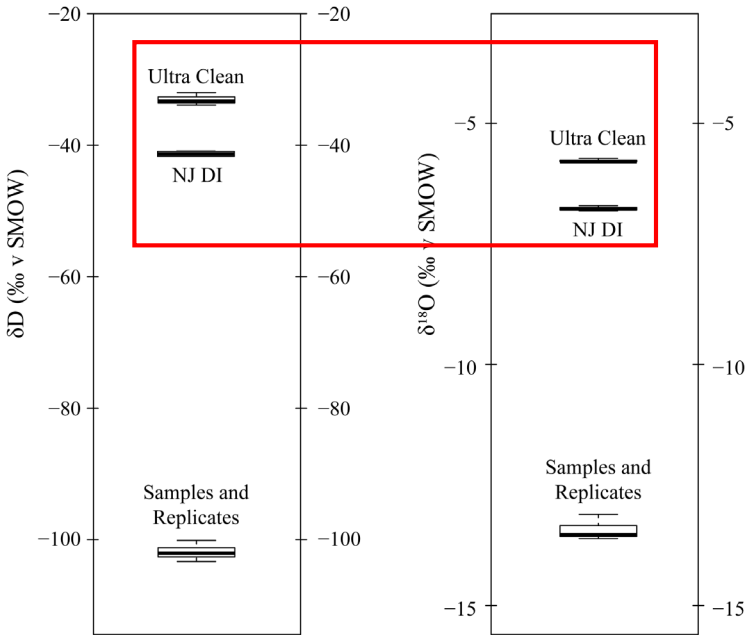
- More stable elements tend to be reproducible and representative
- Oxidizing elements tend to show decreases in concentrations between bailed sample #1 and #10
  - Zinc, Arsenic, Manganese…

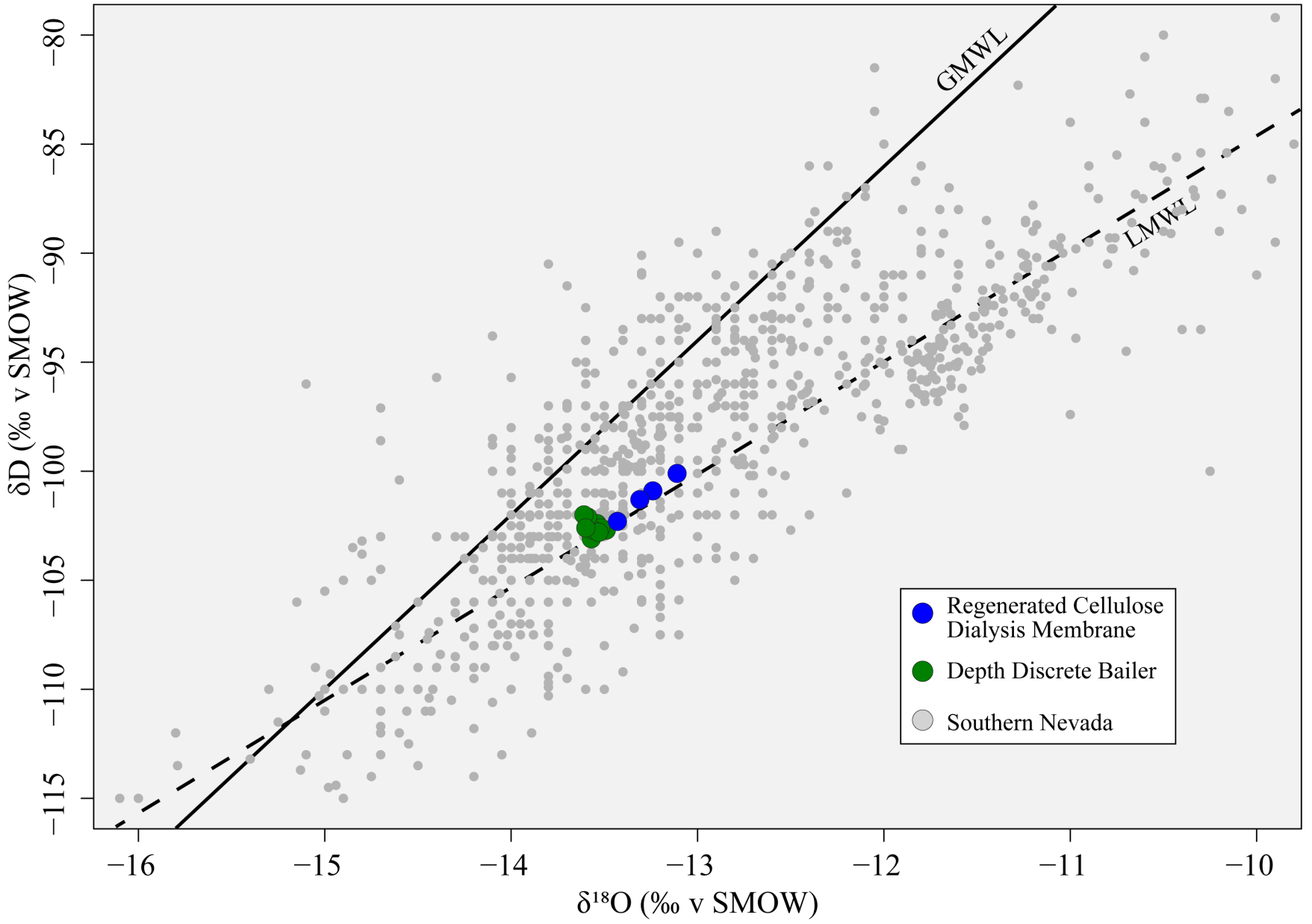
RCDM

- Longer deployment generally shows an increase in average concentrations
- Does not always match available historic data

Stable Isotopes
δD and δ¹⁸O

Field Equipment Blanks





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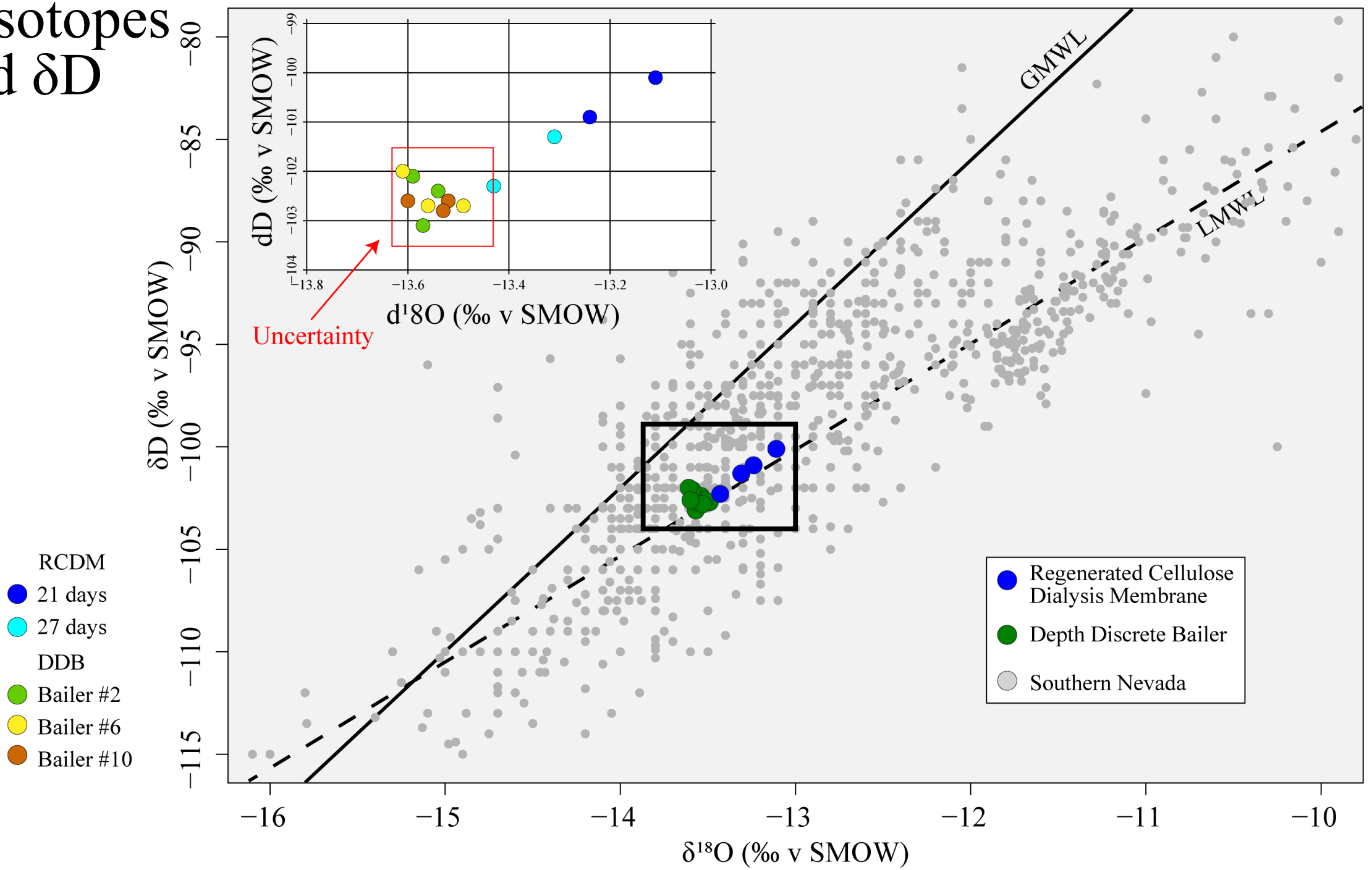
Stable Isotopes
$\delta^{18}O$ and δD



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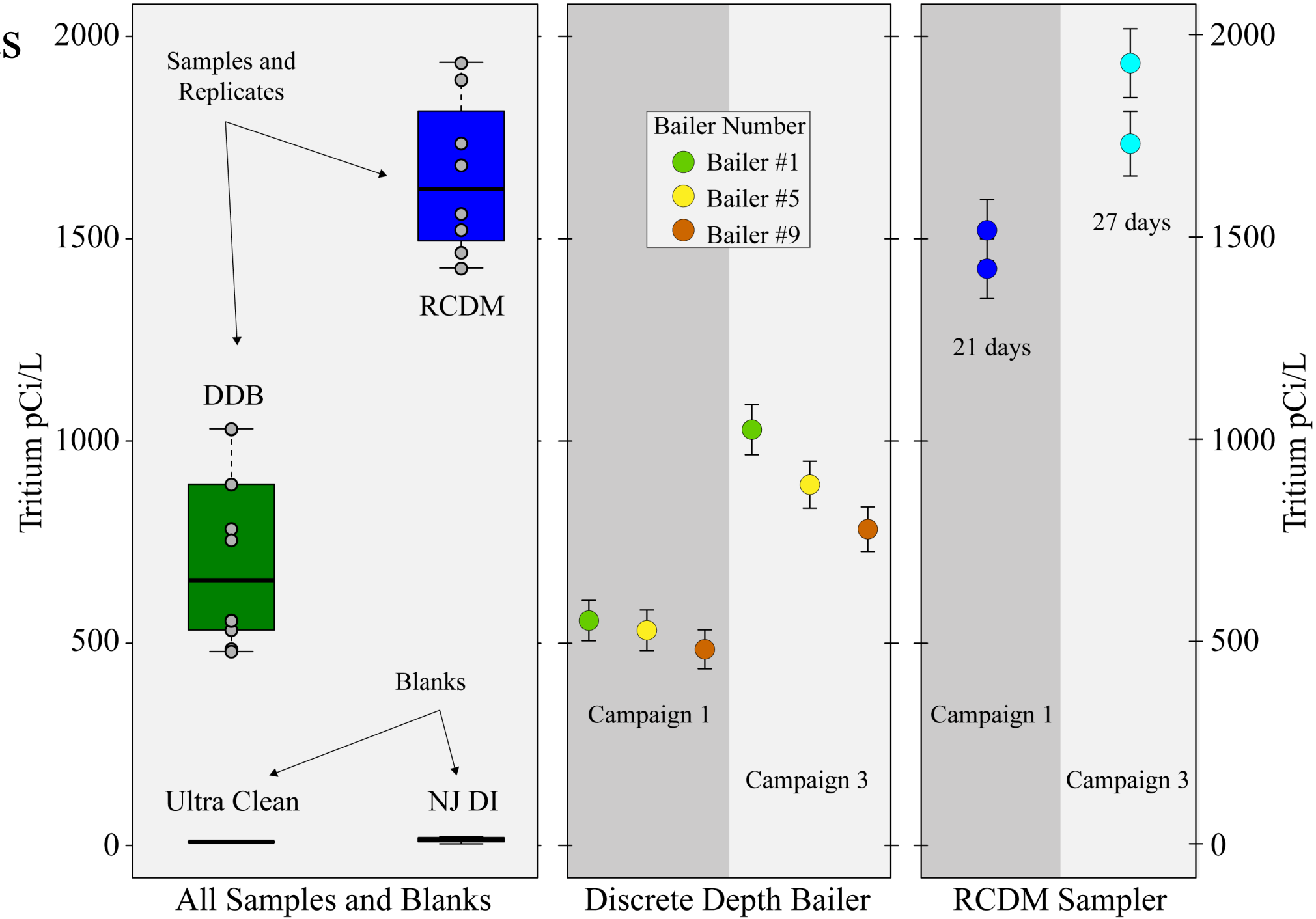
Tritium Results



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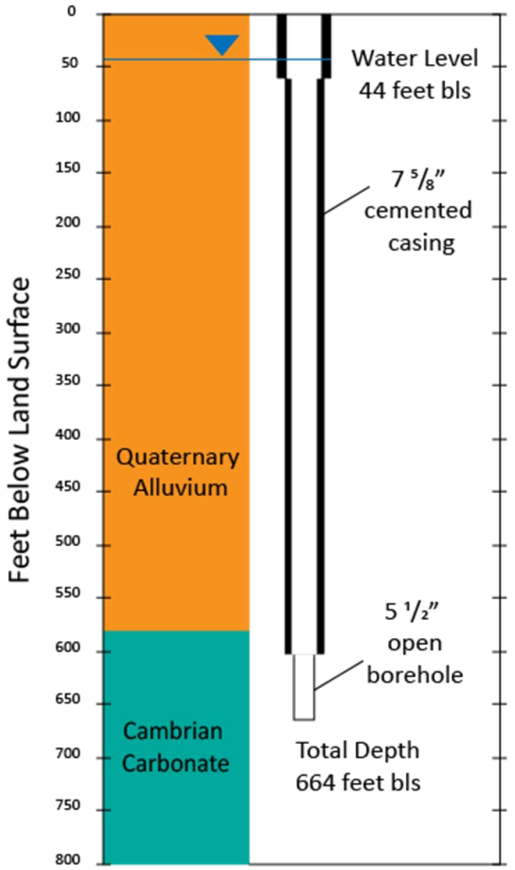
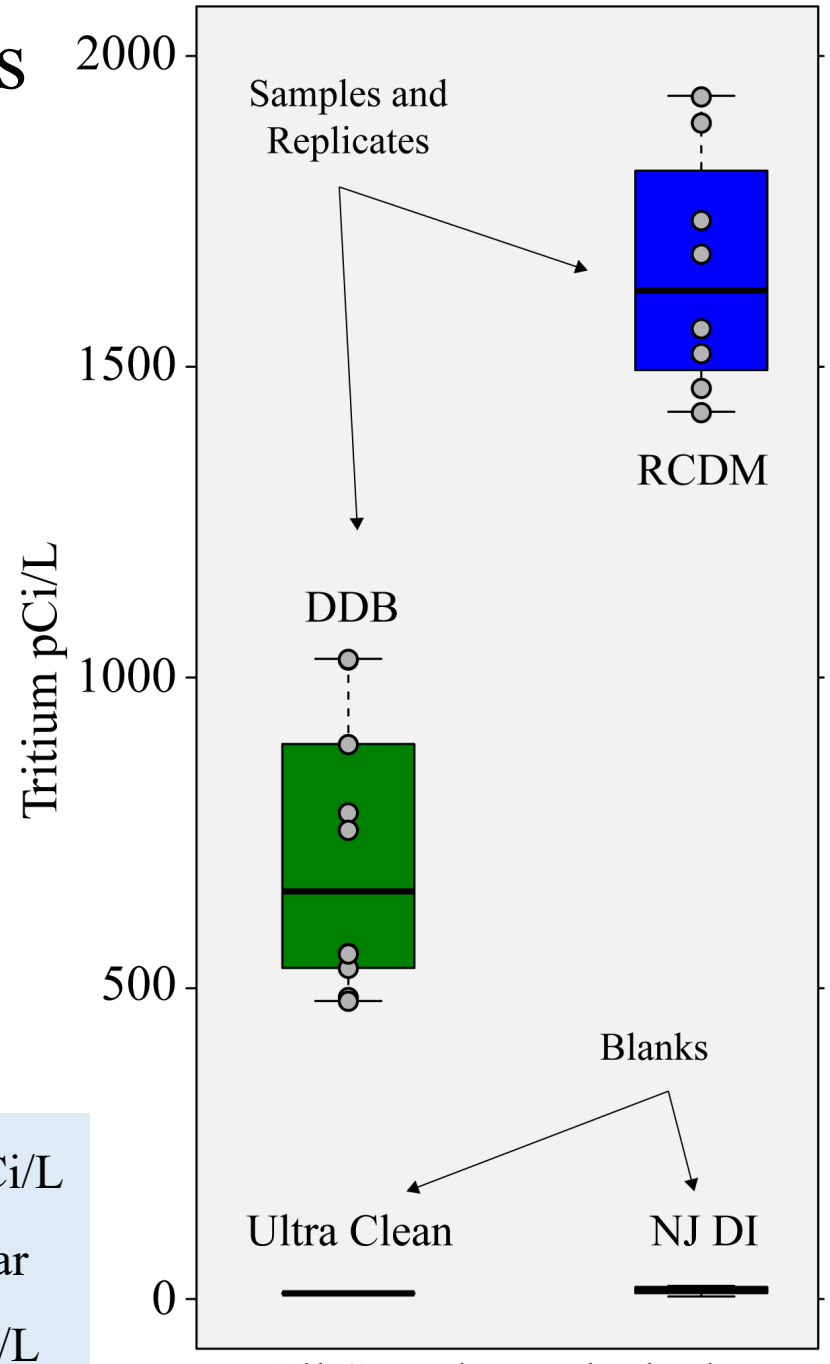
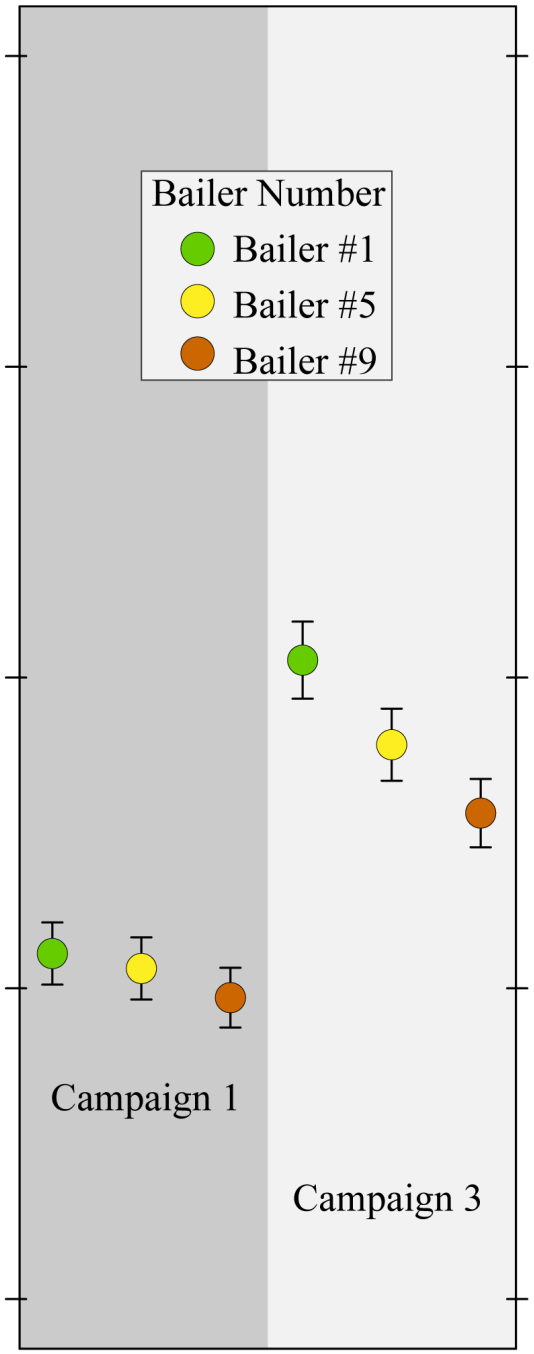


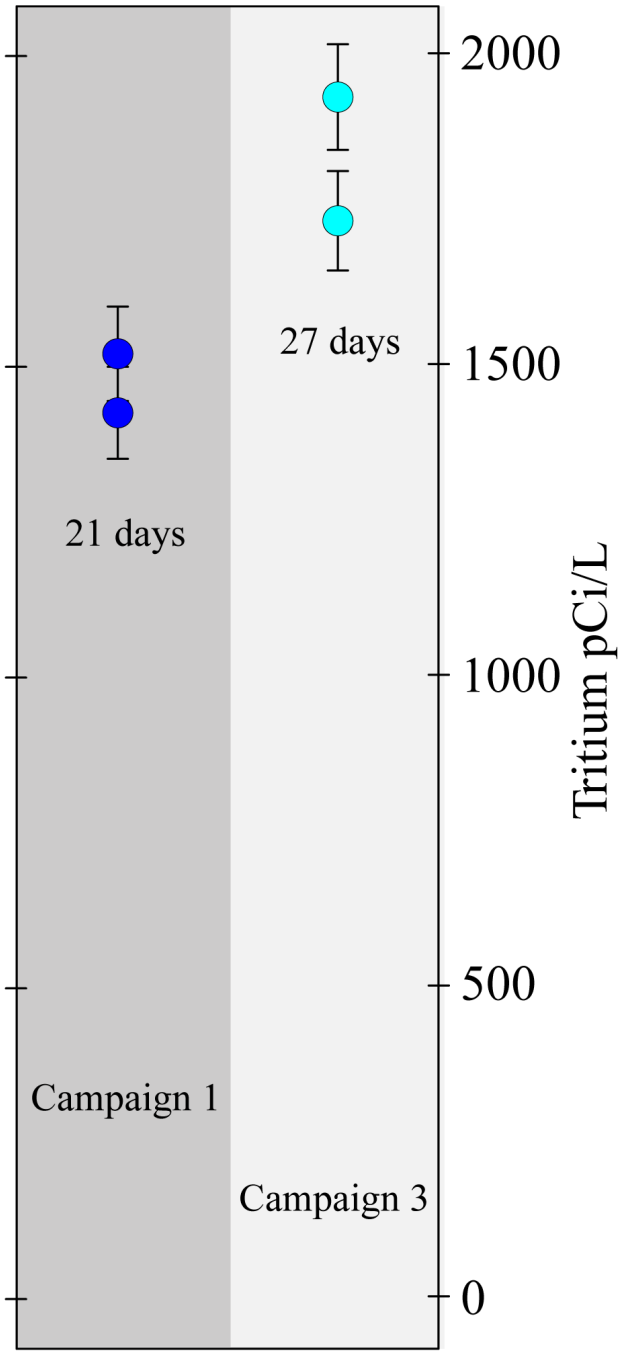
1971 Tritium = 26,000 pCi/L

Tritium ½ life = 12.35 year

2018 Tritium = 3,250 pCi/L







Future Work

In the Lab

Bench test for tritium

- Accumulation vs Equilibrium
- Fractionation across membrane
- Time curve to determine deployment

In the Field

At Tracer Sample Hole #1

- Pump test
  - Micro-purge sample in the casing and at the open hole

Other locations

- Deeper wells and variable transmissivities
- Stratification sampling
- Compare to full volume purge pumped tests

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Thank You. Any Questions?

Thanks to my sampling and design team!
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